TFS item #4a

Vers. 2.3 travel model, trip generation: Development of trip production model

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Acknowledgements

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Background

- As described in the previous presentation, prior to trip generation, demographic models are used to disaggregate zonal HHs into
  - 4 household income groups
  - 4 household size groups (1, 2, 3, 4+ persons)
  - 4 vehicle availability groups (0, 1, 2, and 3+ vehicles available)
- Sub-allocation is made at the TAZ level
- Trip generation models
  - applied to compute daily person trip productions and attractions by purpose
  - Trip rates reflect both motorized and non-motorized trips
  - Since trip distribution and mode choice address only motorized person trips, a model is used to separate the two groups of trip ends (discussed later today): non-motorized trip end model

Background

- Trip production
  - Cross-classification model
  - Total person trips (motorized and non-motorized) for all trip purposes
    - home-based work (HBW),
    - home-based shop (HBS),
    - home-based other (HBO),
    - non-home-based work (NHW), and
    - non-home-based other (NHO)

Background

- Most cross-classification trip production models use HH size and a wealth variable, e.g., HH income or vehicle availability.

  Example:

Automobile Ownership

HH Size	0	1	2+
1	1.19	2.57	1.70
2	1.43	3.16	2.17
3	1.45	4.55	4.74
4+	2.02	4.40	5.05

Graphic from "Urban Transportation Planning," Meyer & Miller, 1984.

- We are using two wealth variables
  - In Ver. 2.2, TD is income stratified and MC is stratified by vehicle availability
  - In Ver. 2.3, both TD & MC are income stratified, but we have continued to stratify by vehicle availability, since this is such an important policy variable

Existing trip production model

HBW Trip Production Rates, 1994 HTS

Income Level	HH Size	Vehicles 0	1	2	3+	Sub-Total
1	1	0.69	0.85	0.75	0.96	**0.79**
	2	1.08	1.08	1.41	1.41	**1.22**
	3	1.10	1.52	1.94	1.94	**1.66**
	4+	1.66	1.66	1.94	1.94	**1.81**
	Subtotal	**0.91**	**1.07**	**1.58**	**1.74**	**1.20**
2	1	1.02	1.18	1.30	1.53	**1.17**
	2	1.35	1.35	1.53	2.12	**1.53**
	3	1.66	1.66	1.79	2.12	**1.85**
	4+	1.85	1.85	2.05	2.43	**2.10**
	Subtotal	**1.21**	**1.34**	**1.73**	**2.23**	**1.61**
3	1	1.02	1.22	1.22	1.22	**1.20**
	2	1.46	1.46	1.84	2.15	**1.77**
	3	1.66	1.66	2.02	3.02	**2.36**
	4+	2.30	2.30	2.30	3.08	**2.55**
	Subtotal	**1.31**	**1.46**	**2.03**	**2.87**	**2.04**
4	1	1.33	1.33	1.33	2.00	**1.34**
	2	1.45	1.45	1.84	2.15	**1.80**
	3	1.67	1.67	2.02	3.02	**2.43**
	4+	3.33	3.33	3.33	3.36	**3.35**
	Subtotal	**1.67**	**1.72**	**2.34**	**3.05**	**2.42**
	TOTAL	**1.05**	**1.33**	**2.02**	**2.72**	**1.85**

- Estimated from the 1994 HTS in 1999
  - *FY-99 Models Development Program for COG/TPB Travel Models*, Draft report, June 30, 1999.
- Used in Ver. 2, 2.1, and 2.2 travel models
- Example shown here: HBW

Methodology

- Estimated using unweighted data (in this case, 2007 HTS)
  - We plan also to compare with estimation using weighted data
- Trip rates developed by dividing the number of sampled trips in each cell by the corresponding number of sampled households
- Initial trip rates computed were reviewed and checked for logic and consistency.
  - Which led to a manual adjustment of some rates ("smoothing"), as deemed necessary.
  - Such adjustments are common given that household sample sizes in some cells are low and may yield unreasonable rates, in comparison to the rates of adjacent cells with larger samples.
  - Cells associated with low income levels and high family sizes, for example, are usually under-represented in travel surveys

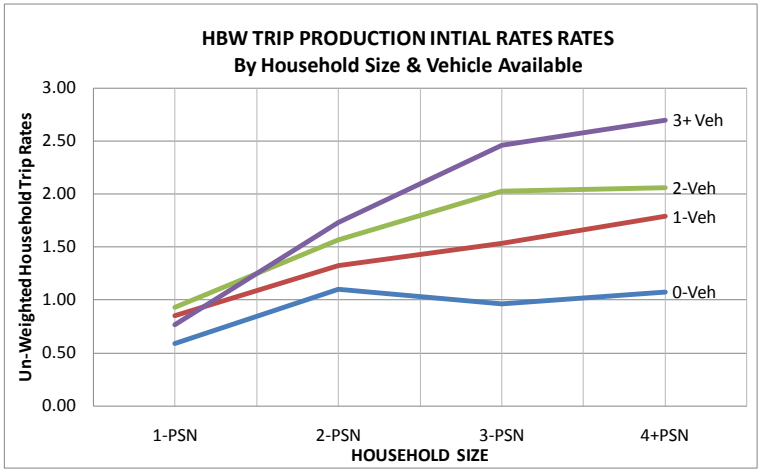
Methodology
Example, HBW, initial rates

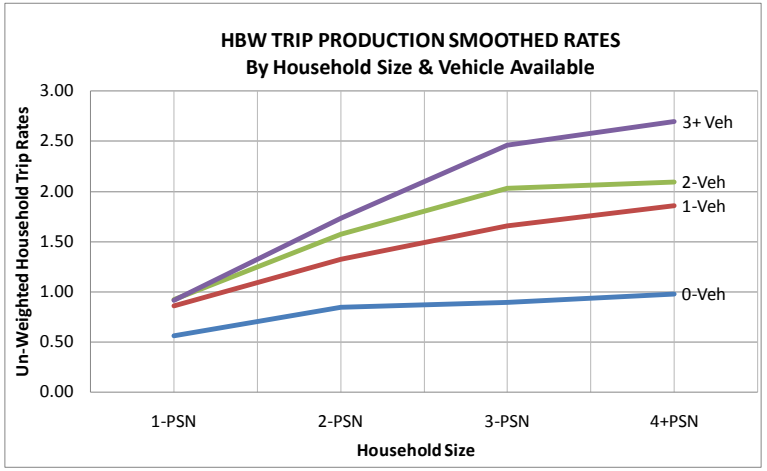
Income Level	HH Size	0-Veh	1-Veh	2-Veh	3+Veh	Sub Total
00k - 50k	1-PSN	0.40	0.59	0.61	0.72	0.54
	2-PSN	0.67	0.78	1.16	1.40	0.97
	3-PSN	0.89	1.44	1.81	1.81	1.53
	4+PSN	0.90	1.76	2.16	2.62	1.97
	Sub-Total	0.48	0.73	1.27	1.64	0.84
50k-100k	1-PSN	0.98	1.00	0.99	0.85	1.00
	2-PSN	1.57	1.29	1.35	1.46	1.36
	3-PSN	2.00	1.68	1.94	2.16	1.95
	4+PSN	1.00	1.76	2.01	2.62	2.20
	Sub-Total	1.13	1.14	1.53	1.98	1.42
100k-150k	1-PSN	1.33	1.03	1.11	0.76	1.05
	2-PSN	2.00	1.77	1.77	1.87	1.80
	3-PSN	0.00	1.38	2.05	2.46	2.15
	4+PSN	3.00	1.78	2.00	2.63	2.23
	Sub-Total	1.64	1.32	1.84	2.28	1.82
> 150k	1-PSN	1.25	0.89	1.00	0.64	0.91
	2-PSN	1.40	2.07	1.84	1.97	1.90
	3-PSN	0.00	1.48	2.30	2.88	2.55
	4+PSN	0.00	1.95	2.20	2.91	2.49
	Sub-Total	1.31	1.49	1.95	2.48	2.06
	TOTAL	0.72	1.05	1.69	2.20	1.49

- There are many dimensions to review
- We look for cases where the values do not monotonically increase
- It is easier to see when the data is graphed in two dimensions (next two slides)

Methodology
Initial and smoothed rates, HBW

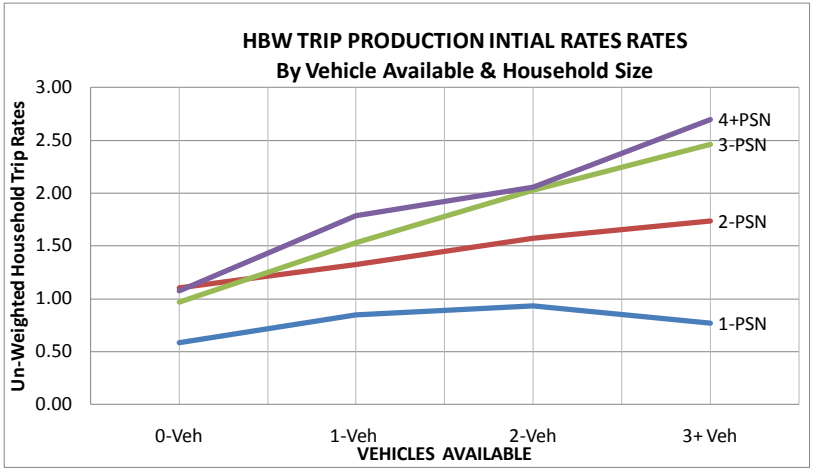
- HBW trip production rates as a function of
  - **HH size and vehs. avail.**
- Before smoothing:
  - Purple line (3+ veh. HHs) crosses other lines
  - Blue line (0 veh. HHs) is kinked
- After smoothing:
  - Purple line no longer crosses others
  - Blue line is smoothed

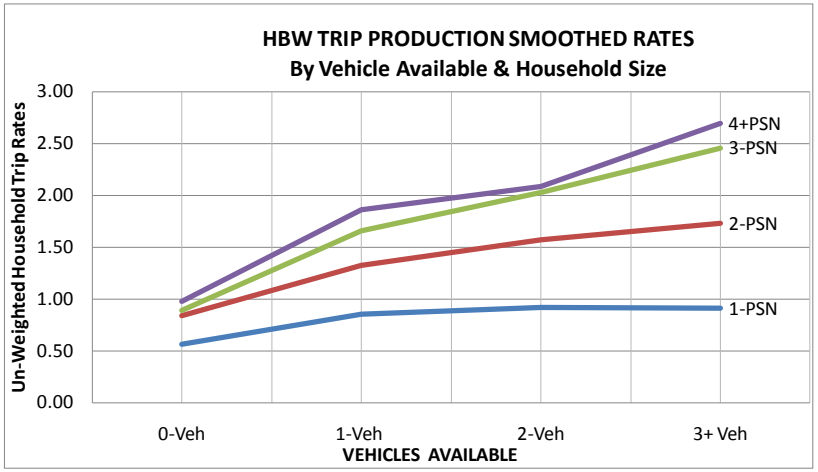




Methodology
Initial and smoothed rates, HBW

- HBW trip production rates as a function of
  - **Vehs. avail. and HH size**
- Before smoothing:
  - Red line (2-psn HHs) crosses other lines
  - Blue line (1-psn HHs) is not monotonically increasing
- After smoothing:
  - Red line no longer crosses others
  - Blue line is now monotonically increasing





Adjusted trip rates (total person trips, motorized and non-motorized)

HBW, adjusted trip rates (total person trips, motorized and non-motorized)

Income Level	HH Size	0-Veh	1-Veh	2-Veh	3+Veh	Sub Total
00k - 50k	1-PSN	0.40	0.59	0.61	0.72	0.54
	2-PSN	0.67	0.78	1.16	1.40	0.97
	3-PSN	0.89	1.44	1.81	1.81	1.53
	4+PSN	0.90	1.76	1.76	2.62	1.82
	Sub-Total	0.48	0.73	1.22	1.64	0.83
50k-100k	1-PSN	0.96	1.00	0.99	0.85	0.99
	2-PSN	0.67	1.29	1.35	1.46	1.33
	3-PSN	1.00	1.68	1.94	2.16	1.95
	4+PSN	1.00	1.76	2.01	2.62	2.20
	Sub-Total	0.89	1.14	1.53	1.98	1.41
100k-150k	1-PSN	1.03	1.03	1.03	1.11	1.03
	2-PSN	1.70	1.77	1.77	1.87	1.79
	3-PSN	1.70	1.77	2.05	2.46	2.19
	4+PSN	1.75	2.00	2.00	2.63	2.24
	Sub-Total	1.30	1.36	1.83	2.29	1.82
> 150k	1-PSN	1.03	1.11	1.11	1.11	1.11
	2-PSN	2.00	2.07	1.84	1.97	1.90
	3-PSN	1.70	2.07	2.30	2.88	2.60
	4+PSN	2.00	2.20	2.50	2.91	2.66
	Sub-Total	1.40	1.66	2.03	2.49	2.12
	TOTAL	0.65	1.07	1.69	2.20	1.49

Notes:

1) Estimated with unweighted trips

2) Includes smoothing, i.e., some cells values adjusted to ensure logical and consistent values from cell to cell

HBS, adjusted trip rates (total person trips, motorized and non-motorized)

Income Level	HH Size	0-Veh	1-Veh	2-Veh	3+Veh	Sub Total
00k - 50k	1-PSN	0.59	0.64	0.66	0.66	0.63
	2-PSN	0.82	1.14	1.14	1.14	1.10
	3-PSN	0.96	1.38	1.38	1.38	1.32
	4+PSN	0.96	1.34	1.76	1.76	1.53
	Sub-Total	0.66	0.82	1.16	1.25	0.88
50k-100k	1-PSN	0.58	0.67	0.67	0.67	0.66
	2-PSN	0.86	1.28	1.33	1.33	1.30
	3-PSN	0.96	0.96	1.67	1.67	1.51
	4+PSN	0.96	1.57	2.08	2.08	2.01
	Sub-Total	0.66	0.85	1.44	1.62	1.19
100k-150k	1-PSN	0.68	0.68	0.68	0.67	0.68
	2-PSN	1.24	1.27	1.31	1.31	1.30
	3-PSN	0.96	1.59	1.59	1.67	1.62
	4+PSN	1.50	1.65	2.13	2.08	2.08
	Sub-Total	0.92	0.98	1.53	1.67	1.43
> 150k	1-PSN	0.80	0.80	0.80	0.80	0.80
	2-PSN	1.24	1.27	1.31	1.38	1.32
	3-PSN	1.24	1.71	1.59	1.70	1.66
	4+PSN	1.50	2.23	2.40	2.42	2.40
	Sub-Total	0.97	1.18	1.58	1.77	1.58
	TOTAL	0.68	0.88	1.47	1.65	1.24

Notes:

1) Estimated with unweighted trips

2) Includes smoothing, i.e., some cells values adjusted to ensure logical and consistent values from cell to cell

Adjusted trip rates (total person trips, motorized and non-motorized)

HBO, adjusted trip rates (total person trips, motorized and non-motorized)

Income Level	HH Size	0-Veh	1-Veh	2-Veh	3+Veh	Sub Total
00k - 50k	1-PSN	0.78	0.92	1.12	1.12	0.90
	2-PSN	0.78	1.61	2.04	2.04	1.71
	3-PSN	1.61	2.93	2.93	2.93	2.75
	4+PSN	1.61	3.71	3.71	4.88	3.70
	Sub-Total	0.85	1.30	2.20	2.70	1.46
50k-100k	1-PSN	0.78	0.92	1.14	1.14	0.94
	2-PSN	0.78	2.10	2.10	2.23	2.08
	3-PSN	1.23	3.79	3.79	3.79	3.78
	4+PSN	2.25	6.44	6.44	6.44	6.41
	Sub-Total	0.82	1.58	3.10	3.93	2.49
100k-150k	1-PSN	0.90	0.93	1.14	1.14	0.97
	2-PSN	1.61	1.97	1.97	1.97	1.96
	3-PSN	2.50	3.79	3.79	3.79	3.79
	4+PSN	2.50	6.44	7.34	7.34	7.28
	Sub-Total	1.23	1.76	3.66	4.41	3.35
> 150k	1-PSN	0.90	0.93	1.14	1.14	0.98
	2-PSN	1.61	1.97	1.99	1.97	1.98
	3-PSN	2.50	4.81	3.88	4.81	4.45
	4+PSN	2.50	6.40	6.40	7.63	6.94
	Sub-Total	1.18	2.14	3.25	4.45	3.47
	TOTAL	0.88	1.55	3.21	4.16	2.63

Notes:

1) Estimated with unweighted trips

2) Includes smoothing, i.e., some cells values adjusted to ensure logical and consistent values from cell to cell

NHW, adjusted trip rates (total person trips, motorized and non-motorized)

Income Level	HH Size	0-Veh	1-Veh	2-Veh	3+Veh	Sub Total
00k - 50k	1-PSN	0.28	0.34	0.34	0.34	0.32
	2-PSN	0.27	0.29	0.39	0.39	0.34
	3-PSN	0.35	0.63	0.63	0.67	0.60
	4+PSN	0.30	0.63	0.63	0.91	0.65
	Sub-Total	0.28	0.36	0.44	0.55	0.37
50k-100k	1-PSN	0.28	0.73	0.73	0.73	0.69
	2-PSN	0.27	0.78	0.78	0.78	0.76
	3-PSN	0.83	0.83	0.83	0.95	0.87
	4+PSN	0.83	0.83	0.88	1.05	0.94
	Sub-Total	0.30	0.75	0.80	0.91	0.77
100k-150k	1-PSN	0.28	0.95	0.95	0.95	0.91
	2-PSN	0.97	0.98	0.98	0.98	0.98
	3-PSN	0.97	1.00	1.15	1.15	1.13
	4+PSN	0.98	1.04	1.04	1.33	1.15
	Sub-Total	0.56	0.97	1.02	1.16	1.03
> 150k	1-PSN	0.79	1.00	1.00	1.00	0.99
	2-PSN	0.79	1.12	1.12	1.12	1.12
	3-PSN	1.26	1.26	1.26	1.37	1.32
	4+PSN	1.26	1.26	1.26	1.43	1.33
	Sub-Total	0.79	1.09	1.17	1.28	1.19
	TOTAL	0.31	0.67	0.91	1.07	0.81

Notes:

1) Estimated with unweighted trips

2) Includes smoothing, i.e., some cells values adjusted to ensure logical and consistent values from cell to cell

Adjusted trip rates (total person trips, motorized and non-motorized)

NHO, adjusted trip rates (total person trips, motorized and non-motorized)

Income Level	HH Size	0-Veh	1-Veh	2-Veh	3+Veh	Sub Total
00k - 50k	1-PSN	0.56	0.67	0.84	0.96	0.65
	2-PSN	0.61	1.22	1.22	1.22	1.14
	3-PSN	0.74	1.22	1.22	1.22	1.15
	4+PSN	1.15	1.15	1.50	1.50	1.34
	Sub-Total	0.59	0.83	1.19	1.24	0.88
50k-100k	1-PSN	0.56	0.67	0.84	1.03	0.69
	2-PSN	0.61	1.22	1.22	1.48	1.24
	3-PSN	0.74	1.45	1.45	1.60	1.50
	4+PSN	1.15	1.49	2.14	2.45	2.17
	Sub-Total	0.58	0.86	1.39	1.80	1.20
100k-150k	1-PSN	0.56	0.67	0.84	1.03	0.71
	2-PSN	0.95	1.22	1.29	1.48	1.31
	3-PSN	1.00	1.45	1.45	1.60	1.51
	4+PSN	1.15	1.49	2.15	2.45	2.23
	Sub-Total	0.73	0.94	1.52	1.85	1.45
> 150k	1-PSN	0.56	0.67	0.84	1.03	0.72
	2-PSN	0.95	1.22	1.53	1.60	1.51
	3-PSN	1.00	1.45	1.53	1.60	1.57
	4+PSN	1.49	2.45	2.45	2.45	2.45
	Sub-Total	0.71	1.11	1.72	1.85	1.66
	TOTAL	0.60	0.88	1.47	1.79	1.26

Notes:

1) Estimated with unweighted trips

2) Includes smoothing, i.e., some cells values adjusted to ensure logical and consistent values from cell to cell

All purposes combined, adjusted trip rates (total psn trips, mot. & non-mot.)

Income Level	HH Size	0-Veh	1-Veh	2-Veh	3+Veh	Sub Total
00k - 50k	1-PSN	2.60	3.16	3.57	3.80	3.04
	2-PSN	3.15	5.03	5.95	6.19	5.26
	3-PSN	4.55	7.60	7.97	8.01	7.35
	4+PSN	4.92	8.58	9.36	11.68	9.04
	Sub-Total	2.87	4.04	6.22	7.38	4.42
50k-100k	1-PSN	3.15	3.99	4.36	4.41	3.97
	2-PSN	3.19	6.67	6.78	7.28	6.72
	3-PSN	4.76	8.72	9.68	10.17	9.60
	4+PSN	6.19	12.10	13.55	14.65	13.75
	Sub-Total	3.25	5.18	8.25	10.24	7.05
100k-150k	1-PSN	3.45	4.26	4.64	4.90	4.31
	2-PSN	6.47	7.20	7.32	7.61	7.34
	3-PSN	7.13	9.60	10.02	10.67	10.25
	4+PSN	7.88	12.63	14.66	15.84	14.99
	Sub-Total	4.74	6.01	9.55	11.38	9.09
> 150k	1-PSN	4.08	4.51	4.89	5.08	4.60
	2-PSN	6.59	7.65	7.79	8.03	7.83
	3-PSN	7.70	11.31	10.56	12.36	11.59
	4+PSN	8.75	14.55	15.02	16.85	15.79
	Sub-Total	5.05	7.18	9.74	11.84	10.03
	TOTAL	3.12	5.05	8.75	10.88	7.43

Notes:

1) Estimated with unweighted trips

2) Includes smoothing, i.e., some cells values adjusted to ensure logical and consistent values from cell to cell

Comparison with 1994

Observed rates

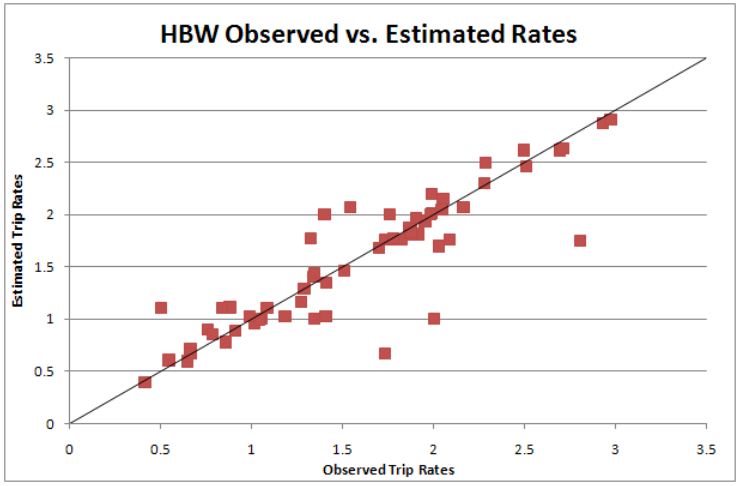
Average Trip Production Rates, daily trips per HH			
(derived from un-weighted survey data)			
			Pct
	1994	2007	Diff
Purp.	HTS	HTS	(07/94)
HBW	1.85	1.49	-20%
HBS	0.88	1.21	37%
HBO	2.88	2.62	-9%
NHB	2.13	2.08	-2%
TOTAL	7.74	7.40	-4%

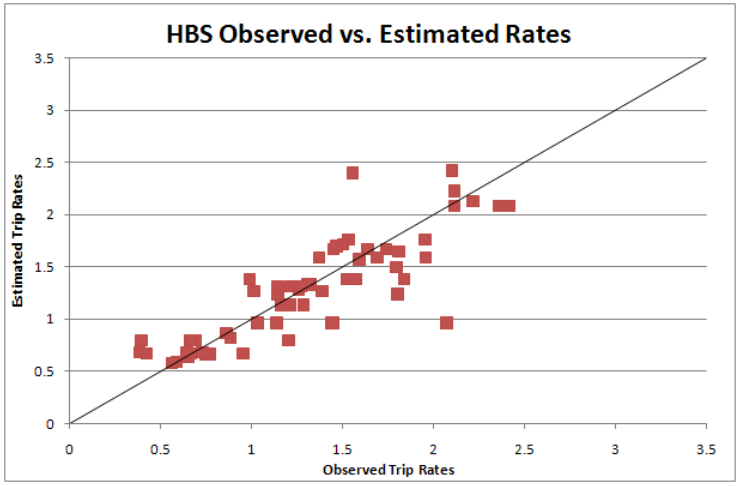
Notes:

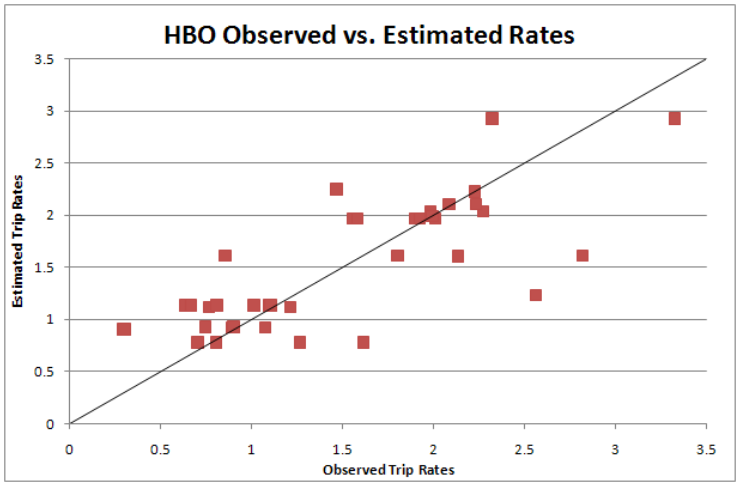
1) For 1994 HTS, HBW is total person trips, but non-work is only motorized person trips
2) For 2007 HTS, All trip purposes are total person trips, i.e., motorized and non-motorized together
3) For comparison purposes with 1994, 2007 NHW & NHO have been added to get one rate for NHB (2.08)

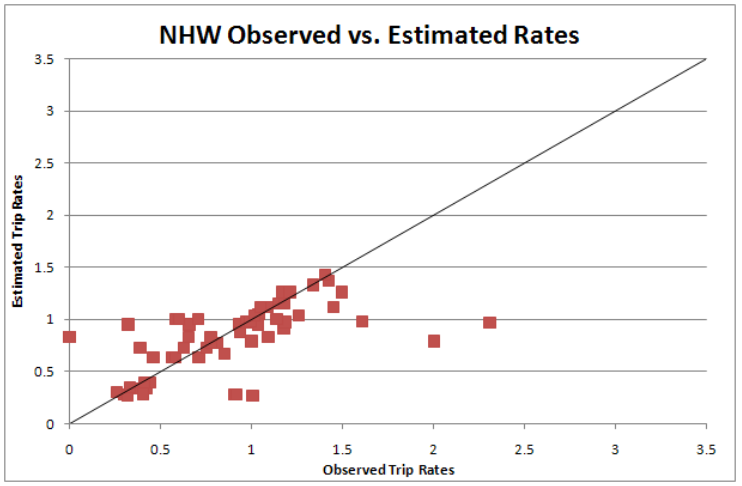
- Only HBW has tot. psn. trips for both 1994 & 2007
- Drop in HBW trip rate of 20%
- Overall drop of 4%
- Possible causes
  - More retired people
  - Increased telecommuting
  - Increased trip chaining
  - Increased use of social networking web sites

Model applied to 64 strata









Summary and conclusions

- Cross classification trip production models developed using 2007/2009 HH Travel Survey for five trip purposes (HBW, HBS, HBO, NHW, NHO), total person trips for all five
- Compared to the last time the models were estimated using the 1994 HTS, trip rates are down, with the exception of HBS (could be due to methodological differences)
- Drop in trip rates echoes findings from R. Griffiths on the 2007 HTS and also national trends (e.g., David T. Hartgen and Elizabeth San Jose, *Costs and Trip Rates of Recent Household Travel Surveys,* November 11, 2009, pp 9-10).
- A technical memo is being prepared
- Next steps
  - We plan also to compare with estimation using weighted data
  - In the past, we have needed to apply a factor of about 1.5 to non-work trip rates, due to underreporting of trip, to ensure proper assigned VMT (issue of underreporting to be addressed)